

Appln No. 10/044,413

Amdt date February 28, 2005

Reply to Office action of August 26, 2004

**Amendments to the Claims:**

This listing of claims will replace all prior versions, and listings, of claims in the application:

**Listing of Claims:**

Claims 1.-8. (Cancelled)

Claim 9. (Currently Amended) A method of decoding transmitted bits to recover a data signal, the method comprising:

receiving a stream of transmitted bits, the transmitted bits being encoded in accordance with an extended low density parity check matrix, the extended low density parity check matrix having an extended portion formed of a plurality of blocks of an original low density parity check matrix, each block having the same number of elements and elements within each block having the same relationship to each other within the original low density parity check matrix, the blocks of the extended portion of the original low density parity check matrix being formed of elements below a <sup>pseudo</sup>-pseudo-diagonal of the original low density parity check matrix; and

iteratively decoding the transmitted bits.

Claim 10. (Currently Amended) A forward error correction system using iteratively decoded codes, the system comprising:

an encoder, the encoder encoding information symbols to form code symbols, the code symbols comprising sets of code symbols, a current set of code symbols comprising a number of code symbols formed of information symbols and a number of code

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symbols formed using information symbols, code symbols of a previous set of code symbols, and previously formed code symbols of a current set of code symbols;

a decoder, the decoder iteratively decoding the code symbols;-

wherein the number of code symbols formed using information symbols, code symbols of a previous set of code symbols, and previously formed code symbols of a current set of code symbols is formed using an XOR operation;

wherein the XOR operation is accomplished in accordance with a linked low density parity check (LDPC) code;

wherein the linked LDPC code is formed by extending a portion of an original LDPC matrix;

wherein the portion of the original LDPC matrix comprises a base portion, an upper extending portion, and a sideways extending portion;

wherein the base portion, the upper extending portion, and the sideways extending portion contain an equal number of elements;

wherein the base portion originates about a lower corner of the original LDPC matrix;

wherein each element of the upper extending portion is above each element of the base portion; and

wherein each element of the sideways extending portion is to the side of each element of the base portion.

Claims 11.-15. (Cancelled)

Claim 16. (New) The system of claim 10 wherein the portion of the original LDPC matrix comprising the base portion, the

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SW upper extending portion, and the sideways extending portion is  
formed of a number of blocks below a <sup>pseudo</sup>psuedo-diagonal of the  
original LDPC matrix. ^

Claim 17. (New) The system of claim 16 wherein the psuedo-diagonal delineates a series of blockwise elements about a lower left corner of the original LDPC matrix.

Claim 18. (New) The system of claim 17 wherein each of the base portion, the upper extending portion, and the sideways extending portion each form a block.

Claim 19. (New) The system of claim 18 wherein each block has its elements in the same relation to one another within the original LDPC matrix.

Claim 20. (New) The system of claim 19 wherein each block includes a plurality of elements.

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use in a systematic iteratively decoded code. In a method comprising forming a first set of code symbols by forming a number

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of code symbols from a first set of data symbols and forming a second number of code symbols using the first set of data symbols and the previously formed code symbols.

SMS

SMS

At least some of the second number of code symbols are formed using code symbols that were formed using a previously formed set of code symbols. In a further embodiment

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the method further comprises forming a second set of code symbols. The second set of code symbols are formed by forming a further second number of code symbols from a second set of data symbols and forming further second member of code symbols using the second set of data symbols and previously formed code symbols. At least some of the further second member of code symbols are formed using at least some of the second member of code symbols.

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In a further embodiment of the invention, the invention comprises a method of forming code bits for use in a system employing a linked low density priority check code. The method comprises receiving a data stream comprising data bits  $d_1 \dots d_{1A}$ ,  $d_2 \dots d_{2A} \dots d_y \dots d_{yA} \dots d_x \dots d_{xA} \dots$ . The method further comprises forming a code stream comprising code bits  $c_1 \dots c_{1A} \dots c_{1B}$ ,  $c_2 \dots c_{2A} \dots c_{2B} \dots c_y \dots c_{yA}$ ,  $c_{yA+1} \dots c_{yB} \dots c_x \dots c_{xA}$ ,  $c_{xA+1} \dots c_{xB} \dots$  where  $c_x \dots c_{xA}$  are  $d_x \dots d_{xA}$ . At least some of the bits  $c_{xA+1} \dots c_{xB}$  are an XOR combination of prior bits including at least some of the bits  $c_{yA+1} \dots c_{yB}$ .

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A further embodiment of the invention provides a forward error correction system. The forward error correction system uses iteratively decoded codes. The system comprises an encoder. The encoder encodes information symbols to form code symbols. The code symbols are comprised of sets of code symbols, a current set of code symbols comprising a number of code symbols formed of information symbols and a number of code symbols formed using information symbols, code symbols with a previous set of code symbols, and previously formed code symbols of a current set of

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using the information words. The encoder provides the code words to a transmitting unit 17. The transmitting unit transmits the code words over a transmission media 18. In one embodiment, the transmission media is a fiberoptic line and the code words are transmitted serially over the fiberoptic line. In another embodiment, the transmitting unit is an RF transmitter and the code words are transmitted through space.

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After the code words are passed through the transmission media, the code words are received by a receiving unit 19. Upon receipt by the receiving unit the code words are provided to a decoder 20. The decoder decodes and corrects the received signal, thereby extracting the information signal.

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The present invention uses, in one embodiment, a linked LDPC code. Aspects of the linked LDPC code may be understood with respect to Fig. 4. Fig. 4 illustrates a parity check matrix 41 in accordance with aspects of the present invention. Preferably, the parity check matrix is a low density parity check matrix with the matrix primarily comprised of zeros, with ones sparsely populating the matrix. For purposes of example, however, the parity check matrix of Fig. 4 has a relatively heavy weighting of ones.

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As illustrated, a portion 43 of the matrix is extended. The extended portion may be viewed as originating approximate a lower left corner 45 of an original matrix 47, and being placed above approximate an upper left corner 49 of the original matrix. The extended portion is formed of a number of matrix elements below a <sup>pseudo</sup> pseudo-diagonal 51 of the matrix. The <sup>pseudo</sup> pseudo-diagonal delineates a series of blockwise elements 53a,b,c, about the lower left corner of the matrix. Thus, the <sup>The</sup> original matrix of Fig. 4 is an 8 x 6 matrix. The extended portion includes a first block 53a comprised of the elements (5,1), (5,2), (6,1), and (6,2). A second block 53b is formed of elements (7,1), (7,2), (8,1), and (8,2). A third block 53c is formed of elements (7,3), (7,4), (8,3), and (8,4). The second element therefore forms a base block in the lower left corner of the original matrix. The first block is an upward extending block extending upward from

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SWB

SMD

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the base block. The third block is a sideways extending block extending sideways into the original matrix from the base block.

5 In operation, the extended portion pertains to, and is correlated with, previously transmitted data. The main portion of the matrix pertains to, and is correlated with, subsequently transmitted data. The subsequently transmitted data, therefore, is linked with the previously transmitted data.

10 Decoding using the parity check matrix of Fig. 4 may be described with respect to Fig. 5. Fig. 5 illustrates parity checks using the parity check matrix of Fig. 4 on a received transmitted data stream. The received transmitted data stream includes a series of sets 61a,n of transmitted code words resulting in received words. Each set of transmitted code words has two data bits 63a,b and six parity check bits 65c-f. Each of the bits of the received word <sup>has</sup> have three parity checks 67, and each of the parity checks uses four bits 69. The code, therefore, is a (3,4) code.

15 Using a set of data and parity bits from an approximate midpoint of a transmission stream as an example, it may be seen that parity checks utilize parity bits from a previously transmitted set in the series of sets. For example, a first parity check 71 uses bits from an nth received set 61n and bits from an n-1 received set 61n-1. Similarly, some of the parity bits from the current series are used in parity checks for subsequently transmitted series. For example, a second parity check 73 uses 20 bits from the nth received word and from an n+1 received word.

25 As illustrated in Fig. 5, the two data bits do not include parity checks from a removed portion 75 of the parity check matrix. Instead, a portion of the removed portion is extended from operation on a prior set. This extended portion 77 is used to generate parity check bits used for checking data bits. 30 Similarly, some of the parity check bits also have parity checks performed on them using portions of the extended matrix. Finally, a portion of the parity bits are used for checks in subsequent sequences.

35 Thus, in one embodiment, transmitted bits other than a first set of data bits have parity checks which depend on previously